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Capoeta coadi, a new species of cyprinid fish from the Karun River drainage, Iran based on morphological and molecular evidences (Teleostei, Cyprinidae)

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Abstract

As presently recognized, the genus *Capoeta* includes 24 species, nine of which are known to occur in Iran (*C. aculeata*, *C. capoeta*, *C. buhsei*, *C. damascina*, *C. fusca*, *C. heratensis*, *C. mandica*, *C. saadii* and *C. trutta*) and are distributed in almost all Iranian basins except Sistan and Mashkid. *Capoeta coadi* **sp. n.** is a new species from the Karun River, southern Iran, draining into the Arvand Rud (Shatt al-Arab) which drains into the Persian Gulf. It is distinguished from all other species of *Capoeta* by the combination of the following characters: elongate and usually cylindrical body; 8–9 branched dorsal-fin rays; last unbranched dorsal-fin ray weakly to moderately ossified and serrated along 1/3–2/3 of its length; scales small; 70-84 in lateral line (total); 12–17 scales between dorsal-fin origin and lateral line; 9-11 scales between anal-fin origin and lateral line; 26–32 circum-peduncular scales; 10–13 gill rakers on lower limb of first gill arch; 45–47 total vertebrae; one posterior pair of barbels; bright golden-greenish or silvery body coloration in life; length of the longest dorsal-fin ray 15–22% SL; head length 23–26% SL; mouth width 7–10% SL. *Capoeta coadi* is also distinguished from all other congeners in the Iranian drainages by fixed diagnostic nucleotide substitutions in the mtDNA COI barcode region and *cyt b*. It is nested in the *Capoeta damascina* species complex.

Keywords

Capoeta damascina species complex, COI, *Cyt b*, Persian Gulf, phylogenetic relationships

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Introduction

The Middle East is a transition zone between three major biogeographic units, the Palaearctic, the Afrotropical, and the Oriental realms. It served as an important crossroad of biotic exchange resulting in an outstanding biological diversity of freshwater fishes (Durand et al. 2002, Krupp et al. 2009). Lying between major drainages of the Nile in Africa to the west, the Indus in southern Asia to the east and the Caspian and Black Sea drainages to the north, the Tigris-Euphrates River drainage is the largest river system in the Middle East and has high fish diversity, especially in cyprinid fishes.

Capoeta Valenciennes in Cuvier and Valenciennes 1842 is an example of a cyprinid genus widely spread in the Middle East (Krupp and Schneider 1989). Being found in a wide range of habitats, species of this genus display considerable morphological variability (e.g., scale counts and colour pattern) and the extent of morphological plasticity and genetic variability remain to be determined. As a consequence, there has been considerable disagreement regarding the status of several species. However, *Capoeta* is considered monophyletic (Krupp 1985, Küçük et al. 2009).

Members of the genus *Capoeta* are cyprinids characterized by having an elongate, cylindrical body and a short dorsal fin. They have three to five unbranched and 5–9 branched dorsal-fin rays, the last unbranched ray being ossified and serrated. All species have three unbranched and 5 branched anal-fin rays. Scales are usually small. Mouth is inferior and the lower lip is covered with a horny sheath. One pair of barbels (rarely two) is present and the pharyngeal teeth are arranged in three rows. The shape of the mouth as well as the pharyngeal teeth are nearly identical in all species, which indicate their adaptation to the same mode of feeding. This combination of character states distinguishes *Capoeta* from all other cyprinids (Krupp 1985, Krupp and Schneider 1989).

As presently recognized, the genus *Capoeta* includes about 24 species (Eschmeyer and Fricke 2016) in different phylogenetic groups widely distributed in many river drainages and basins in southwestern Asia except the Arabian Peninsula (Alwan 2011, Levin et al. 2012). Levin et al. (2012) studied the phylogenetic relationships of the genus *Capoeta* based on complete mitochondrial gene for cytochrome *b* sequences obtained from 20 species from the overall range of the genus. Three main groups were detected: the Mesopotamian group (*Capoeta trutta* group), the Anatolian-Iranian group (*Capoeta damascina* group) and the Aralo-Caspian group (*Capoeta capoeta* group).

Members of the *Capoeta damascina* species group, characterized by having small scales, include *C. buhsei* Kessler, 1877, *C. caelestis* Schöter, Özuluğ & Freyhof, 2009, *C. damascina* (Valenciennes, 1842), *C. kosswigi* Karaman, 1969, *C. saadii* (Heckel, 1847), and *C. umbla* (Heckel, 1843) (Alwan 2011). Based on phylogenetic analyses of cytochrome c oxidase subunit I (COI) and the large subunit (LSU or 28S) ribosomal RNA gene sequences Alwan (2011) identified two main lineages within what we will refer to in this paper, as the "*C. damascina* species complex". A western lineage is represented by *C. caelestis*, *C. damascina* and *C. umbla* and an eastern lineage represented by *C. buhsei*, *C. saadii*, and a new undescribed species.

Traditionally, *C. damascina* is recorded from Tigris, Mond, Kor, Esfahan, Dasht-e Kavir, Namak Lake, Kor River, Lake Maharlu, Persian Gulf (now Persis), Kerman-Na'in, Dasht-e Lut, Sirjan, Hormuz, and Hamun-e Jaz Murian basins in Iran (Nikol'skii 1899, Berg 1949, Kähsbauer 1964, Armantrout 1980, Rainboth 1981, Bianco and Banarescu 1982, Ghorbani Chafi 2000, Jalali et al. 2005, Esmaeili et al. 2010, Bahrami Kamangar et al. 2012). Its distribution over such wide range of isolated water bodies, raises questions regarding the status of *C. damascina*. Currently, *C. damascina* s.l. represents a complex of closely related species with high intraspecific and comparatively low interspecific variation (Alwan 2011, Levin et al. 2012). Now, three species of *Capoeta* from Iranian water bodies are recognized as being members of *C. damascina* species complex group: *C. buhsei*, *C. saadii* (Iranian populations were considered as *C. damascina*) (see Alwan 2011, Levin et al. 2012), and a new undescribed species from the Karun (Karoun) River drainage. It is described here as a new species, *Capoeta coadi*.

Material and methods

After anaesthesia, fishes were either fixed in 5% formaldehyde, and stored in 70% ethanol, or directly fixed in 99% ethanol (for molecular studies). Measurements were made with a digital caliper and recorded to 0.01 mm. All measurements were made point to point, and never by projections. Methods for counts and measurements follow Hubbs and Lagler (1958) and Krupp (1983). Standard length (SL) was measured from the tip of the snout to the end of the hypural complex. The length of the caudal peduncle was measured from behind the base of the last anal-fin ray to the end of the hypural complex. The last two branched rays articulating on a single pterygiophore in the dorsal and anal fins are counted as "1½".The holotype is included in the calculation of means and SD.

Abbreviations used: SL, standard length; HL, lateral head length.

Abbreviations used for museum collections: Zoological Museum of Shiraz University, Collection of Biology Department, Shiraz, Iran (ZM-CBSU), the Senckenberg Research Institute and Natural History Museum (SMF: Frankfurt, Germany), and the private collection of Jörg Freyhof (FSJF: Fischsammlung J. Freyhof).

DNA extraction and PCR amplification protocol

For DNA sequencing, specimens were directly fixed in 99% molecular grade ethanol. Mitochondrial DNA was extracted using Salt method (Bruford et al. 1992). The standard vertebrate DNA barcode region of the COI (cytochrome c oxidase subunit 1) and cytochrome *b* (*cyt b*) were amplified using primer pairs named FishF1-5'TCAACCAACCACAAAGACATTGGCAC3' and FishR1-5'TAGACTTCTGGGTGGCCAAAGAATCA3' (Ward et al. 2005) and L14724-

5'GTGACTTGAAAAACCACCGTTG3' and H15915-5'CAACGATCTCCGGTTT-AGAAGAC3' (Xiao et al. 2001) or GluF- 5'AACCACCGTTGTATTCAACTACAA3' and H-15560 5`TAGGCRAATAGGAAR TATCA3` (Machordom and Doadrio 2001), respectively.

Purification and sequencing of the PCR products were conducted at Macrogen Korea Laboratories using the aforementioned primer sets.

Molecular data analyses

Data processing and sequence assembly was done in BioEdit 7.2.5 (Hall 1999); MEGA6 (Tamura et al. 2013) was used to create a DNA sequence alignment. No indications of unexpected stop-codons or nuclear copies of mitochondrial fragments occurred in any sequences. All generated DNA barcodes and *cyt b* were deposited in the NCBI GenBank. The most appropriate sequence evolution model for the given data was determined with Modeltest (Posada and Crandall 1998) as implemented in the MEGA6 software, treating gaps and missing data with the partial deletion option under 95% site coverage cut-off. The model with the lowest BIC (Bayesian Information Criterion) score is considered the best model to describe the substitution pattern for each gene. To explore species phylogenetic relationships, trees were generated using Maximum Likelihood analysis with 10,000 bootstrap replicates in RaxML 7.2.5 (Stamatakis 2006) under the GTR+G model of nucleotide substitution, with fast bootstrap and also Bayesian analysis (BA), using the Markov Chain Monte Carlo method (MCMC), with 6,000,000 generations under the most generalizing model (GTR+G+I) using Mr. Bayes 3.1.1 (Huelsenbeck and Ronquist 2001). Screening for diagnostic nucleotide substitutions was performed manually from the sequence alignment. As an appropriate outgroup to root the constructed phylogenetic hypothesis, we included the distantly related *Cyprinus carpio*.

Results

Morphological assessments

***Capoeta coadi* sp. n.**
http://zoobank.org/4B5B0984-0C65-4B6D-97CC-31245E179D13
Figs 1–3

Holotype. ZM-CBSU Z190, 157 mm SL; Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar (Bashar) River at Tale Gah village, Karun River drainage, 30°47'27"N, 51°25'13"E.

Paratypes. ZM-CBSU Z191, 6, 91–157 mm SL; same data as holotype. ZM-CBSU J520, 1, 107 mm SL; ZM-CBSU Z275, 12, 105–152 mm SL; Iran, Koh-

Figure 1. *Capoeta coadi* sp. n., ZM-CBSU Z190, holotype, 157 mm SL; Iran: Kohgiluyeh and Boyer Ahmad, Beshar River, Karun River drainage.

giluyeh and Boyer Ahmad prov., Beshar (Bashar) River at Tale Gah village, Karun River drainage, 30°47'27"N, 51°25'13"E. 15 December 2014, G. Sayyadzadeh, R. Khaefi, A. Khajehpanah. ZM-CBSU J526, 1, 98 mm SL; ZM-CBSU J533, 1, 114 mm SL; ZM-CBSU J535, 1, 97 mm SL; ZM-CBSU J540, 1, 67 mm SL; All from Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Tange sorkh, Karun River drainage, 30°26'14"N, 51°45'48"E. 24 July 2011, R. Zamaneian Nejad, S. Mirgheiasi, S. Ghasemian. ZM-CBSU J444, 2, 73–90 mm SL; ZM-CBSU J447, 2, 76–111 mm SL; ZM-CBSU J450, 1, 86 mm SL; ZM-CBSU J452, 1, 107 mm SL; ZM-CBSU J459, 2, 104–120 mm SL; ZM-CBSU J464, 1, 110 mm SL; all from Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Mokhtar village, Karun River drainage, 30°40'31"N, 51°31'26"E. 25 May 2011, R. Zamaneian Nejad.

Additional material. ZM-CBSU 7880–7881, 2, 96.69–158.12 mm SL; Iran, Fars prov., Sepidan city, Gorgu River, a tributary of Beshar River, north of Sepidan city, Karun River drainage, 30°21.283'N, 51°45.754'E. 2006. H.R. Esmaeili, A. Teimori, M. Ebrahimi and A. Gholamhoseini. SMF 33337, 1, 48.86 mm SL; Iran, Lorestan prov., Hadi River between Zagheh and Polehoru, 33°31.138'N, 48°46.340'E. 04 March 2008. N. Alwan, K. Borkenhagen, M. Ghanbari Fardi and A. Kazemi. FSJF 2213, 11, 107.92–143.94 mm SL; Iran, Chaharmahal and Bakhtiari Prov., Sandgan River (Sandgan stream) at Sandgan, 31°15.692'N, 51°17.150'E. 19 April 2007, A. Abdoli and J. Freyhof. FSJF 2233, 2, 156.22–162.23 mm SL; Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River, 20 km northeast of Yasuj, 30°44.152'N, 51°29.522'E. 19 April 2007. A. Abdoli and J. Freyhof. SMF 30865, 1, 26.94 mm SL; Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Tang-e Sorkh, 30°27.680'N, 51°44.907'E. 28 November 2007, K. Borkenhagen, H. R. Esmaeili and F. Wicker (in 96% alcohol). SMF 30871, 1, 28.34 mm SL; Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Tang-e Sorkh, 30°27.680'N, 51°44.907'E. 28 November 2007. K. Borkenhagen, H. R. Esmaeili and F. Wicker (in 96% alcohol). SMF 33316, 7, 35.22–166.87 mm SL; Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Tang-e Sorkh, 30°27.680'N, 51°44.907'E. 28 November 2007, K. Borkenhagen, H. R. Esmaeili and F. Wicker. SMF 30872, 1, 29.70 mm SL; Iran, Fars prov., Sepidan, Tang-e Tizab, 30°23.470'N, 51°46.710'E, 28 November 2007, K. Borkenhagen, H. R. Esmaeili and F. Wicker (in 96% alcohol).

Figure 2. *Capoeta coadi* sp. n., paratypes: **a** ZM-CBSU Z191; 157 mm SL **b** ZM-CBSU Z192, 148 mm SL; Iran: Kohgiluyeh and Boyer Ahmad, Beshar River, Karun River drainage.

***Capoeta coadi* specimens used for molecular genetic analysis.** ZM-CBSU M1275,1, Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Dehno village, Karun River drainage, 30°38'55"N, 51°37'05"E. 16 January 2014, H.R. Esmaeili, G. Sayyadzadeh, H.R. Mehraban, M. Razbani. GenBank accession number: (COI: KU564296); ZM-CBSU M1447, 2, GenBank accession number: (COI: KU564297, KU564298; cytb: KU564303, KU564304) ZM-CBSU M1458, 2); Iran, Kohgiluyeh and Boyer Ahmad prov., Beshar River at Tale Gah village, Karun River drainage, 30°47'27"N, 51°25'13"E. 14 December 2013. G. Sayyadzadeh, A. Khajehpanah, R. Khaefi. GenBank accession number: (COI: KU564294, KU564295; *cytb*: KU564305, KU564306).

Diagnosis. *Capoeta coadi* sp. n. is distinguished from all other species of *Capoeta* by the following combination of characters: last unbranched dorsal-fin ray weakly to moderately ossified and serrated in 1/3–2/3 of its length; scales small, 70–84 total lateral line scales (84 in holotype), 12–17 scales between dorsal-fin origin and lateral line (16 in holotype), 9–11 scales between anal-fin origin and lateral line (11 in holotype), 26–32 encircling least circumference of caudal peduncle (31 in holotype); total gill rakers 14–18 (17 in holotype), 10–13 gill rakers on lower limb of first gill arch (12 in holotype); 45–47 total vertebrae; one posterior pair of barbels; length of the longest dorsal-fin ray 14.92–21.58% SL (18.90 in holotype); head length 22.87–26.33% SL (23.76 in holotype); mouth width 7.48–9.77% SL (8.65 in holotype); bright golden-greenish or silvery body coloration in life.

Figure 3. Live specimen of *Capoeta coadi* sp. n, Iran: Kohgiluyeh and Boyer Ahmad, Beshar River, Karun River drainage.

Description. General body shape and appearance are shown in Figs 1–3, morphometric data in Table 1 and meristic data are summarized in Tables 2–9. Body elongate and cylindrical; predorsal body profile smoothly convex with no marked discontinuity between head and body except when a nuchal hump is present in few specimens; greatest body depth at level of dorsal-fin origin; snout rounded (in 20 specimens) or pointed (in 14 specimens) and not size dependent; mouth inferior; lips slightly fleshy, especially at the mouth corners; lower lip covered with a sharp-edged horny sheath, its anterior margin straight in adult specimens and rounded to almost crescent-shaped in juveniles, with a considerable degree of individual variation.

Dorsal-fin origin anterior to pelvic-fin origin, its outer margin usually straight to concave with 3–5 unbranched and 8–9 branched rays (3 and 8 in holotype, respectively); last unbranched dorsal-fin ray weakly to moderately ossified, flexible and soft at the tip, serrated in 1/2–2/3 of its length (Fig. 4); pectoral fins not extending to pelvic-fin base; their outer margins usually slightly convex with 16–22 rays in total (19 in holotype) (Table 2); pelvic fins not extending to anal fin base, their outer margin straight or slightly convex and blunt with 7–11 rays in total (8 in holotype) (Table 2); pelvic axillary scale present; anal fin with 3 unbranched and 5 branched rays, outer margin straight or slightly convex; caudal fin forked with 16–19 branched rays (17 in holotype) (Table 3), its tip pointed and its upper lobe often longer than lower one.

Scales small, total lateral-line scales 70–84; 12–17 scales between dorsal-fin origin and lateral line (Table 4); 9–11 scales between anal-fin origin and lateral line (Table 4); 26–32 circum-peduncle scales (Table 5); ventral midline and pectoral region covered with deeply embedded scales of reduced size; gill rakers slightly hooked, total gill rakers 14–18 (10–13 gill rakers on lower limb) of first gill arch (Table 8–9); 45–47 total vertebrae; usually one posterior pair of barbels present (very rarely two, 1 out of 51 individual); pharyngeal teeth arranged in 3 rows in the following manner: 2.3.5–5.3.2 and very similar in shape to those of *C. damascina*; teeth in the main row spatulate or spoon-shaped and crowns flat, narrow and curved.

Table 1. Morphometric data of *Capoeta coadi* sp. n. (holotype ZM-CBSU Z190, and 33 paratypes), *C. buhsei* and *C. saadii*.

	Holotype	Paratypes (n=33)			*Capoeta buhsei* (n=27)			*Capoeta saadii* (n=20)		
		Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Standard length (mm)	157.64	67.23–157.64	110.67		74.30–149.30	112.56		51.31–231	109.30	
In percent of standard length										
Head length	23.76	22.87–26.33	24.5	0.80	21.47–25.98	23.56	0.98	24.28–29.62	26.84	1.32
Body depth at dorsal-fin origin	21.82	21.33–25.04	23.15	0.98	19.78–24.55	21.82	1.19	19.58–27.78	23.32	2.11
Predorsal length	49.07	47.75–53.43	50.23	1.31	48.85–55.05	51.59	1.34	44.33–55.12	51.93	2.51
Postdorsal length	54.13	54.13–63.19	57.53	1.88	48.20–60.13	55.24	2.78	50.79–59.64	55.06	2.60
Preanal length	72.45	70.22–76.14	72.8	1.36	71.34–76.34	74.01	1.28	69.37–78.38	75.61	2.07
Prepelvic length	53.74	50.22–55.90	52.84	1.31	50.17–56.64	53.58	1.49	51.23–61.21	56.22	2.36
Distance between pectoral and pelvic-fin origins	32.42	27.81–32.42	30.19	1.13	29.07–33.64	31.30	1.04	25.55–32.66	30.87	2.15
Distance between pelvic and anal-fin origins	21.48	19.31–23.17	21.12	0.88	19.90–23.65	21.60	0.91	18.32–23.41	20.83	1.56
Depth of caudal peduncle	10.37	10.03–11.61	10.65	0.37	8.58–10.84	10.05	0.50	8.98–11.15	10.43	0.60
Length of caudal peduncle	20.73	17.16–22. 35	19.85	1.14	18.64–22.01	19.81	0.91	15.19–20.11	17.67	1.30
Dorsal-fin base length	12.71	12.27–16.17	14.41	0.89	11.75–15.28	13.51	0.80	10.46–14.39	12.98	1.11
Anal-fin base length	6.78	6.38–8.85	7.39	0.55	6.96–8.80	7.88	0.58	6.24–8.27	7.17	0.60
Pectoral-fin length	17.32	16.68–20.46	18.43	0.89	16.39–20.96	18.38	0.99	16.15–19.16	17.86	1.01
Pelvic-fin length	15.05	14.24–16.96	15.61	0.68	13.85–18.08	15.61	1.08	13.58–16.23	15.08	0.82
Length of the longest dorsal fin ray	18.90	14.92–21.58	19.57	1.27	16.42–21.22	18.78	1.06	16.35–21.53	19.03	1.47
Mouth width	8.65	7.48–9.77	8.63	0.51	6.49–8.89	7.87	0.57	6.51–9.38	8.1	0.73
In percent of head length										
Head depth at eye	56.88	49.05–61.87	54.21	2.73	48.01–56.63	67.01	2.26	49.17–57.97	65.47	3.96
Snout length	38.32	31.60–47.70	38.08	2.60	32.69–38.89	35.55	1.67	32.65–40.61	36.18	2.41
Postorbital distance	48.83	33.82–51.84	48.01	3.01	47.66–56.59	51.57	1.89	46.58–54.84	51.05	2.28
Interorbital width	40.04	34.62–42.81	38.19	1.98	33.88–41.49	37.15	1.93	30.90–40.16	35.57	2.70
Eye diameter	15.97	15.07–23.57	18.52	2.36	13.91–24.44	17.36	2.11	11.95–26.18	18.23	3.43
Maximum head width	60.53	51.75–66.89	59.60	3.99	57.83–69.68	62.76	3.04	47.38–59.00	54.62	3.39
Barbel length	15.14	13.30–20.20	16.25	1.66	15.66–24.60	19.71	2.27	13.34–24.64	18.11	2.73

Table 2. Number of pectoral and pelvic fin rays in examined *Capoeta* species.

	Pectoral fin rays										Pelvic fin rays					
	13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**		**7**	**8**	**9**	**10**	**11**
C. buhsei			2	10	4	6						2	14	10		
C. coadi				6	10	8	11	7	1	3		1	14	16	12	8
C. mandica	1	7	2	1								9	2			
C. saadii					3	12	4	1					9	10	1	
C. trutta		2	8	17	8	5							22	17	1	

Table 3. Number of branched caudal fin rays in examined *Capoeta* species.

Branched caudal fin rays	**15**	**16**	**17**	**18**	**19**	**20**
C. buhsei		3	21	3		
C. saadii		1	29	2	1	
C. mandica		2	8	1		
C. trutta	1	9	16	11	3	

Table 4. Number of scales above (between dorsal-fin origin and lateral line) and below (between dorsal-fin origin and lateral line) lateral line in examined *Capoeta* species.

	Above lateral line												Below lateral line								
	6	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
C. buhsei								3	6	4	12						3	13	7	3	1
C. coadi							1	9	9	15	15	1					11	20	18		
C. mandica							1	10								4	5	2			
C. saadii				1	2	1	8	7	1					2	4	3	9	2			
C. trutta			2	1	1	7	16	7	3	3						7	19	8	6		

Coloration. Live specimens. Dorsum and sides bright golden-green or silvery, darker dorsally and lighter below the lateral line; dorsal head bright golden-green or light pink-brown; dorsal, anal and caudal fins beige to light brown with light pink to red tinge; pectoral and pelvic-fins beige to light brown or golden with brown tinge on the first few rays (Fig. 3); few large black blotches present on the body of some specimens whereas small diffuse black spots are present only on the body of some juveniles (above the lateral line).

Preserved specimens. Dorsum, head and sides grey or brownish-grey dorsally and beige or yellow ventrally; dorsal and caudal fins dusky grey; pectoral, pelvic and anal fins white or beige with or without grey tinge; blotches and spots well discernible (Figs 1–2).

Sexual dimorphism. Breeding tubercles present in both sexes, being bigger and more pronounced in males. Tubercles present on the sides of the snout but may also cover the entire body surface, on and above the lateral line with one or two tubercles per scale but not on each scale, below the lateral line especially in the area above the anal fin and on the branched anal-fin rays; tip of anal fin reaching to or beyond the vertical of the caudal-fin base in females and to about 2/3 of the caudal peduncle in males.

Figure 4. Dorsal fins of *Capoeta coadi* sp. n. **a** ZM-CBSU J 444; 73 mm SL **b** ZM-CBSU Z195; 104 mm SL **c** ZM-CBSU Z192; 148 mm SL; Iran: Kohgiluyeh and Boyer Ahmad, Beshar River, Karun River drainage, to show size-dependent variability of the last simple dorsal-fin ray serration.

Table 5. Number of circum-pendicular scales in examined *Capoeta* species.

	19	21	22	23	24	25	26	27	28	29	30	31	32	33
C. buhsei							1	3	2	5	5	3	4	3
C. coadi							3	11	7	14	4	7	5	
C. fusca	1	6	2	4	1	1								
C. mandica								5	1	3	1			1

Table 6. Number of caudal-peduncle scales in examined *Capoeta* species.

	10	11	12	13	14	15	16	17	18	19	20	21	22
C. buhsei								6	3	7	9	1	1
C. coadi					1	1	2	8	15	2	3	1	
C.mandica					4	2	4		1				
C. saadii					2	1	10	6	1				
C. trutta		1	1		2	3	5	14	8	1	4		1

Habitat and distribution. *Capoeta coadi* sp. n. occurs in medium-fast flowing rivers with usually gravel substrates and clear waters (Fig. 5). At the Beshar River sampling site, the river is about 25 m wide, with substrate consisting of coarse gravel and boulders, and fast-flowing and semi-transparent waters. The physicochemical parameters at the spot were: dissolved oxygen, 9.89 mg/L; total dissolved solids, 190.2 mg/L; salinity, 0.19‰; conductivity, 395 µs/cm; pH: 8.5 and water temperature 23.4 °C. It is known only from the Karun River drainage, a system that constitutes the southeastern part of the Tigris-Euphrates River system.

Etymology. The new species is named after Brian W. Coad, a well-known ichthyologist for his valuable contribution to the knowledge of freshwater fishes of Iran.

Comparative remarks. The presence of one pair of barbels in *Capoeta coadi* sets the species apart from *C. antalyensis*, *C. baliki*, *C. banarescui*, *C. tinca*, and *C. heratensis*, all of which have two pairs of barbels based on data from Turan et al. (2006a) and this study. The new species is further distinguished from *C. antalyensis* by the presence of serrae on the last unbranched dorsal-fin ray (vs. absence) (Fig. 4), and by number of scales between dorsal-fin origin and lateral line (12–17 vs. 10–12 in *C. antalyensis*)

Figure 5. Beshar River at Taleh Gah village, Karun River drainage, type locality of *C. coadi*.

(Table 4), between anal-fin origin and lateral line (9–11 vs. 7), and by total number of the lateral-line scales (70–84 vs. 51–57) (Table 7). *Capoeta coadi* is distinguished from *C. banarescui* by number of scales between anal-fin origin and lateral line (9–11 vs. 8–9) (Table 4). Data for *C. antalyensis* and *C. banarescui* are from Turan et al. (2006a).

Capoeta coadi is distinguished from *C. mandica*, *C. erhani*, and *C. trutta* by having 10–13 gill rakers on the lower limb of the first gill arch (vs. 17–24 in *C. mandica*, 20–22 in *C. erhani* and 18–25 in *C. trutta* [data from Krupp 1985, Turan et al. 2008, Table 8]). The total number of gill rakers in *Capoeta coadi* specimens is 14–18 that is lower than in *C. mandica* (23–27), *C. barroisi* (28–30), *C. turani* (25–30) and *C. trutta* (21–31) [data from Turan et al. (2006b), Özuluğ and Freyhof (2008), and this study] Table 9. *Capoeta coadi* is further distinguished from *C. mandica* by having fewer pectoral fin rays (16–22 vs. 13–16) (Table 2). *Capoeta coadi* is distinguished from *C. bergamae*, *C. capoeta* and *C. sieboldii* by number of scales between dorsal-fin origin and lateral line (12–17 in *C. coadi* vs. 8–10 in *C. capoeta* and 9–11 in *C. sieboldii*); number of scales between anal-fin origin and lateral line (9–11 in *C. coadi* vs. 7–9 in *C. bergamae*, 6–10 in *C. capoeta* and 8–10 in *C. sieboldii*); total lateral line scales (70–84 in *C. coadi* vs. 48–66 in *C. capoeta* and 52–60 in *C. sieboldii*) [data from Banarescu 1999, Turan et al. 2006b, Tables 4, 7]. In addition to the presence of serrae on the unbranched dorsal-fin ray, *Capoeta coadi* is set apart from *C. caelestis* by the number of scales between the dorsal-fin origin and lateral line (12–17 in *C. coadi* vs. 10–13.5

Table 7. Number of lateral-line scales in examined *Capoeta* species.

	58	59	61	62	63	64	65	66	67	68	69	70	71	72	73
C. buhsei														1	
C. coadi												2	1	2	6
C. mandica	1		1	2	1		2	1	2	1					
C. saadii			1				2	1	2	2	1	2	3	1	
C. trutta			1			2		1	3	1	5	4	2	2	2

	74	75	76	77	78	79	80	81	82	83	84	85	87	89
C. buhsei	3		1	2	1	2		4	3	1	2	4	1	1
C. coadi	1	4	4	1	5	3	5	6	5	1	1			
C. mandica														
C. saadii			1	2	2									
C. trutta		5	3	2	4		2				1			

in *C. caelestis*); scales between anal-fin origin and lateral line (9–11 in *C. coadi* vs. 7–8 in *C. caelestis*); circum-peduncular scales (26–32 in *C. coadi* vs. 23–24 in *C. caelestis*) (Tables 4–5) and probably vertebral counts (45–47 in *C. coadi* vs. 44 in *C. caelestis*) [data from Schöter et al. 2009].

It is distinguished from *C. damascina* by having 11–13, modally 13, gill rakers on the lower limb of the first gill arch (vs. 12–18, modally 14–15) (Alwan 2011, Table 8). *Capoeta coadi* is clearly distinguished from *C. ekmekciae* by number of scales between dorsal-fin origin and lateral line (12–17 in *C. coadi* vs. 9–10 in *C. ekmekciae*); number of scales between anal-fin origin and lateral line (9–11 in *C. coadi* vs. 6–7 in *C. ekmekciae*) (Table 4); number of lateral line scales (70–84 in *C. coadi* vs. 55–61 in *C. ekmekciae* [data from Turan et al. 2006b; Alwan 2011].

Capoeta coadi is distinguished from *C. kosswigi* by total number of gill rakers (Table 9): 14–18 in *C. coadi* vs. 19–28 in *C. kosswigi* (see Karaman 1969; Turan et al. 2006b; Turan 2008).

Capoeta coadi is distinguished from *C. mauricii* and *C. pestai* by having a weaker, thinner and less ossified last unbranched dorsal-fin ray in juveniles and adults and fewer scales between dorsal-fin origin and lateral line (12–17 in *C. coadi* vs. 18–22 in *C. mauricii* and 16–19 in *C. pestai* [data from Özuluğ and Freyhof 2008, Küçük et al. 2009]). It is further distinguished from *C. pestai* by the absence of spots on the body except in juveniles (vs. presence of many on the body [see Özuluğ and Freyhof 2008, Küçük et al. 2009]). *Capoeta coadi* is distinguished from *C. umbla* by total number of lateral line scales (70–84 vs. 86–104), number of scales between dorsal-fin origin and lateral line (12–17 vs. 18–24), number of scales between anal-fin origin and lateral line (9–11 vs. 11.5–15.5), and circum-pendicular scales (26–32 vs. 32–39) (see Alwan 2011, Tables 4–7).

Compared to other Iranian species of *Capoeta*, *C. coadi* has more scales and fewer gill rakers than *C. aculeata* (number of scales between dorsal-fin origin and lateral line:

Table 8. Gill rakers on the lower limb of the first gill arch in studied *Capoeta* species.

GR	8	9	10	11	12	13	17	18	19	20	22	24
C. buhsei	2	19	6									
C. coadi			1	9	19	20						
C. mandica							1	2	3	1	3	1

Table 9. Number of total gill rakers on the first gill arch in examined *Capoeta* species.

	12	13	14	15	16	17	18	21	22	23	24	25	26	27	28	31
C. buhsei	10	13	6													
C. coadi			1	7	14	6	5									
C. mandica										2	2	2	1	4		
C. saadii	1	9	6	1	2	1										
C. trutta								1	1	9	11	7	5	4	1	1

12–17 vs. 6–10; number of scales between anal-fin origin and lateral line: 9–11 vs. 5–8; circum-peduncular scales: 26–32 vs. 13–23; total number of lateral line scales: 70–84 vs. 36–52; caudal peduncle scales: 14–18 vs. 10–12; gill rakers on the lower limb of the first gill arch: 10–13 vs. 15–18 [data from Coad and Krupp 1994] and this study (Tables 4–9)). *Capoeta coadi* is distinguished from *C. fusca* by more total vertebrae (45–47 vs. 44), and more total lateral-line scales (70–84 vs. 40–62) (see Coad 2008, Johari et al. 2009).

Capoeta coadi differs from its sister species (see Figs 6–7), *C. buhsei* in having more gill rakers on lower limb of first gill arch (10–13 vs. 8–10), more gill rakers on the whole first gill arch (14–18 vs. 12–14, see Tables 8–9) and by depth of caudal peduncle in percent of standard length (10.03–11.61 vs. 8.58–10.84). *Capoeta coadi* is distinguished from another closely related species, *C. saadii* by having more scales below the lateral line (9–11 vs. 6–10, modally 9) (Table 4) and more circum-pendicular scales (26–32 vs. 23–28, modally 25–26) [data from Alwan (2011)].

Molecular phylogenetic assessments

We generated COI barcode and *cyt b* sequences for a total of 76 and 61 *Capoeta* specimens, respectively (Tables 10–11). Two phylogenetic approaches including Maximum Likelihood and Bayesian analyses for species of *Capoeta* are given in Figs 6–7. Tables 12–13 provide the diagnostic nucleotide substitutions found in the mtDNA COI barcode region and *cyt b*, respectively.

For inter-specific differences, the greatest pairwise genetic divergence between *C. coadi* and its congeners was found to be 6.5 by *C. erhani* and lowest by *C. buhsei* (0.4) for COI and greatest 9.7 by *C. mandica* and lowest (1.5) by *C. buhsei* for *cyt b* (Tables 14–15).

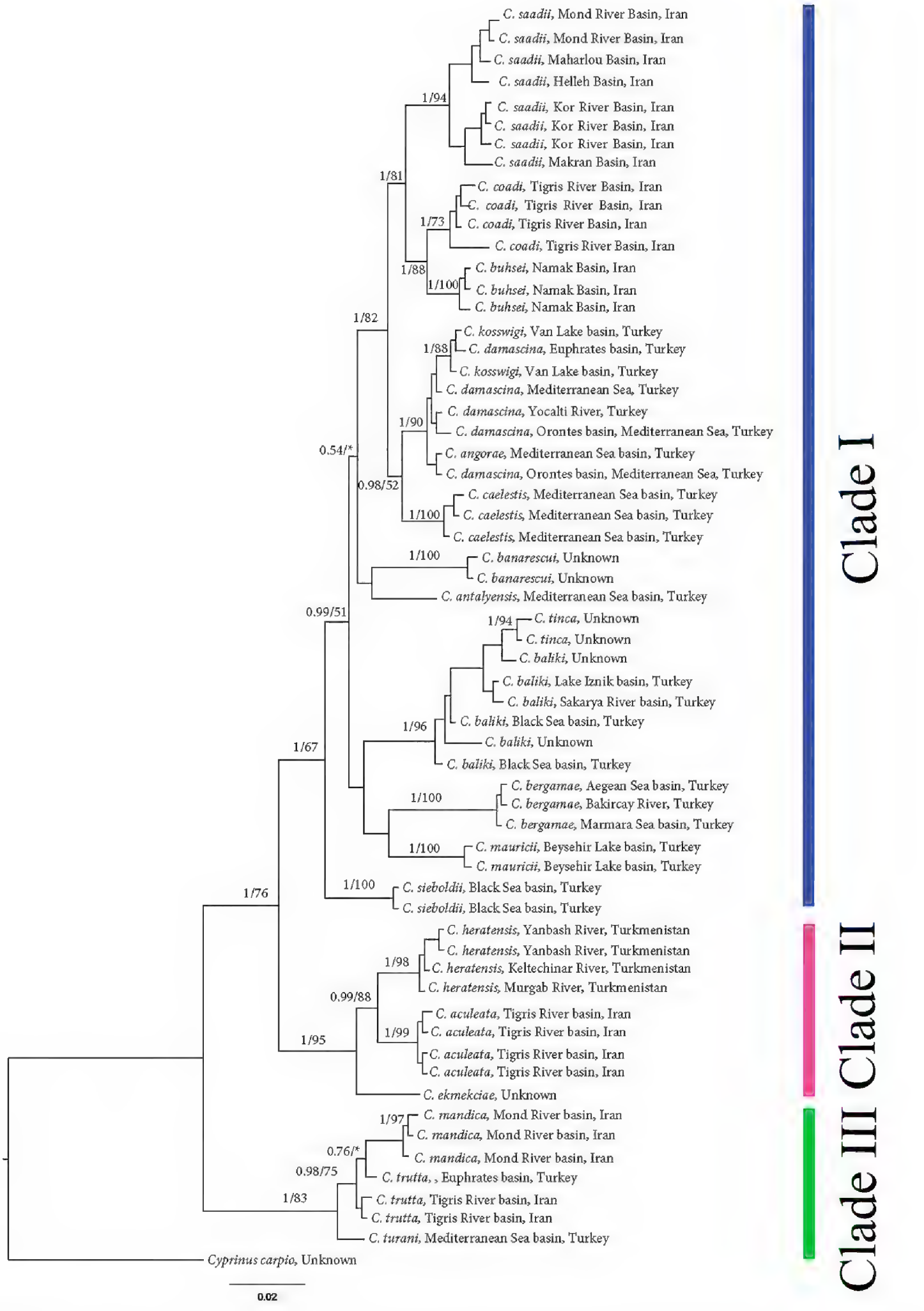

Figure 6. Bayesian tree inferred from *cyt b*. Numbers left of the slash, indicate the posterior probabilities of the Bayesian analysis, using MrBayes, while numbers right of the slash are the bootstrap support for 10,000 replicates in the Maximum Likelihood tree, using RaxML. Asterisks (*) indicate less than 50% Maximum Likelihood support for the node.

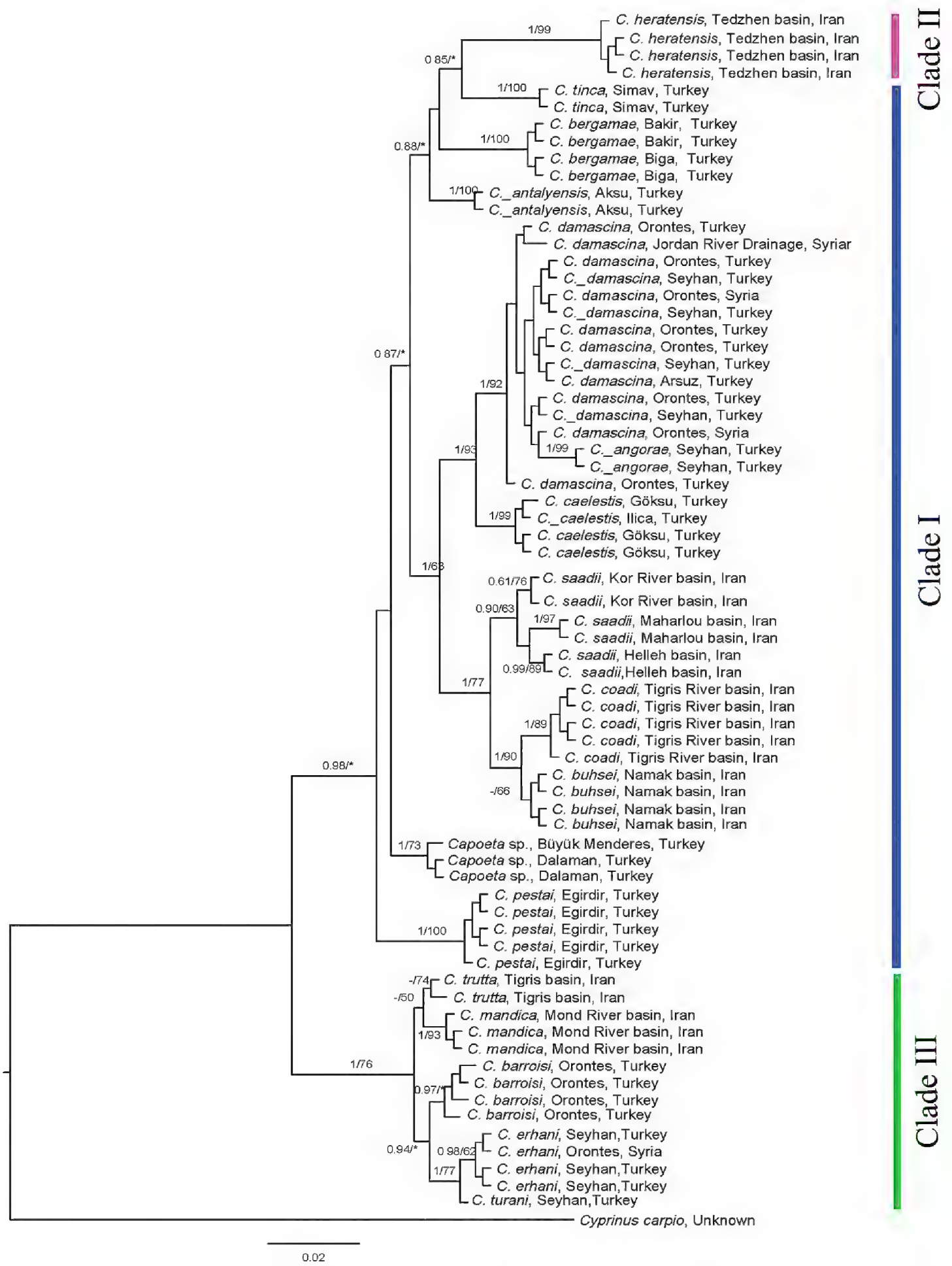

Figure 7. Bayesian tree inferred from COI. Numbers left of the slash, indicate the posterior probabilities of the Bayesian analysis, using MrBayes, while numbers right of the slash are the bootstrap support for 10,000 replicates in the Maximum Likelihood tree, using RaxML. Asterisks (*) indicate less than 50% Maximum Likelihood support and (-) indicates less than 0.50 Bayesian posterior probabilities for the node.

Table 10. List of species used for molecular analysis for *cyt b* (*present study, the ones without * are obtained from GenBank). *Cyprinus carpio* was considered as outgroup.

Species	Accession Number	Locality
C. aculeata	JF798267	Stream Sangan, Karun River basin, Tigris basin, Iran
C. aculeata	JF798264	Sevah River, Kor basin, Iran
C. aculeata	JF798266	Beshar River, Karun basin, Tigris basin, Iran
C. aculeata	JF798265	Sevah River, Kor basin, Iran
C. angorae	JF798268	Pozanti River, Mediterranean Sea basin, Turkey
C. antalyensis	JF798269	Boga Cayi River, Mediterranean Sea basin, Turkey
C. baliki	JF798272	Kizilirmak River, Black Sea basin, Turkey
C. baliki	JF798273	Biggest tributary of Kurtbog˘azi dam lake, Sakarya River basin, Turkey
C. baliki	JF798275	Stream Cakirca, Lake Iznik basin, Turkey
C. baliki	GQ424019	Unknown
C. baliki	GQ424020	Unknown
C. baliki	JF798271	Kizilirmak River, Black Sea basin, Turkey
C. banarescui	GQ423987	Unknown
C. banarescui	GQ423988	Unknown
C. bergamae	JF798282	Bakacak stream, Marmara Sea basin, Turkey
C. bergamae	JF798280	Bakircay River, Turkey
C. bergamae	JF798281	Stream Guzelhisar, Aegean Sea basin, Turkey
C. buhsei	JF798283	Taghra Rud stream, Namak Lake basin, Iran
*C. buhsei**	KU312369	Kordan River, Namak Lake basin, Karaj, Iran
*C. buhsei**	KU312370	Kordan River, Namak Lake basin, Karaj, Iran
C. caelestis	JF798336	Ilica stream, Gulf of Antalya, Mediterranean Sea basin,Turkey
C. caelestis	JF798286	Goksu River, Mediterranean Sea basin, Turkey
C. caelestis	JF798287	Kargi Cayi River, Mediterranean Sea basin, Turkey
*C. coadi**	KU564303	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564304	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564305	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564306	Beshar River, Tigris River basin, Iran
C. damascina	JF798309	Karadut River, Euphrates basin, Turkey
C. damascina	JF798303	Stream Arsuz, Iskenderun Gulf basin, Mediterranean Sea, Turkey
C. damascina	JF798308	Yocalti River, Turkey
C. damascina	JF798306	Spring Incesu, Orontes basin, Mediterranean Sea, Turkey
C. damascina	JF798307	Yocalti River, Mediterranean Sea basin, Turkey
C. ekmekciae	GQ424027	Unknown
C. heratensis	JF798319	Keltechinar River, Turkmenistan
C. heratensis	JF798318	Yanbash River, Turkmenistan
C. heratensis	JF798317	Yanbash River, Turkmenistan
C. heratensis	JF798316	Murgab River, Turkmenistan
C. kosswigi	JF798322	Deli Cayi River, Van Lake basin, Turkey
C. kosswigi	JF798323	Deli Cayi River, Van Lake basin, Turkey
C. mandica *	KU564307	Ghare Aghaj River, Mond River basin, Khaneh Zanian , Iran
C. mandica *	KU564308	Ghare Aghaj River, Mond River basin, Khaneh Zanian , Iran
C. mandica *	KU312375	Ghare Aghaj River, Mond River basin, Khaneh Zanian , Iran

Species	Accession Number	Locality
C. mauricii	JF798325	Eflatum spring, Beysehir Lake basin, Turkey
C. mauricii	JF798324	Sarioz stream, Beysehir Lake basin, Turkey
*C. saadii**	KU564309	Ghare Aghaj River, Mond River basin, Firuzabad, Iran
*C. saadii**	KU564310	Ghare Aghaj River, Mond River basin, Firuzabad , Iran
*C. saadii**	KU564311	Saadii Tomb Spring, Maharlu basin, Iran
*C. saadii**	KU312373	Helleh River, Helleh basin, KohmarSorkhi, Iran
*C. saadii**	KU564312	Kor River, Kor basin, Kamfirouz, Iran
*C. saadii**	KU564313	Kor River, Kor basin, Kamfirouz, Iran
C. saadii	JF798326	Rodan River, Makran basin, Iran
C. saadii	JF798327	Spring Golabii, 35 km north from Darab, Hormuz basin, Iran
C. sieboldii	JF798329	Kizilirmak River, Black Sea basin, Turkey
C. sieboldii	JF798330	Kelkit Cayi River, Black Sea basin, Turkey
C. tinca	GQ424008	Unknown
C. tinca	GQ424007	Unknown
C. trutta	JF798334	Dez River, Karun River basin, Iran
C. trutta	JF798333	Sultansuyu River, Euphrates basin, Turkey
C. trutta	JF798332	Gelal River, Ab e Seymareh, Tigris River basin, Iran
C. turani	JF798335	Çatkit River, Mediterranean Sea basin, Turkey
Cyprinus carpio	DQ868875	Unknown

Table 11. List of species used for molecular analysis for COI (*present study, the ones without * are obtained from GenBank). *Cyprinus carpio* was considered as outgroup.

Species	Accession num.	Locality
*C. heratensis**	KU564288	Gilas spring, Tedzen basin, Iran
*C. heratensis**	KU564289	Gilas spring, Tedzen basin, Iran
*C. heratensis**	KU564290	Gilas spring, Tedzen basin, Iran
*C. heratensis**	KU564291	Bezangan Lake, Tedzen basin, Iran
C. angorae	KJ553074	Seyhan, Turkey
C. angorae	KJ552868	Seyhan, Turkey
C. antalyensis	KJ552850	Aksu, Turkey
C. antalyensis	KJ553025	Aksu, Turkey
C. barroisi	KJ553267	Orontes, Turkey
C. barroisi	KJ553245	Orontes, Turkey
C. barroisi	KJ552785	Orontes, Turkey
C. barroisi	KJ552810	Orontes, Turkey
C. bergamae	KJ553157	Bakir, Turkey
C. bergamae	KJ552877	Bakir, Turkey
C. bergamae	KJ553253	Biga, Turkey
C. bergamae	KJ553081	Biga, Turkey
*C. buhsei**	KU312349	Kordan River, Namak Lake basin, Karaj, Iran
*C. buhsei**	KU312350	Kordan River, Namak Lake basin, Karaj, Iran
*C. buhsei**	KU564292	Roudbar River, Kavir basin,Iran

Species	Accession num.	Locality
*C. buhsei**	KU564293	Roudbar River, Kavir basin,Iran
C. caelestis	KJ552856	Göksu, Turkey
C. caelestis	KJ553237	Ilica, Turkey
C. caelestis	KJ553301	Göksu, Turkey
C. caelestis	KJ553030	Göksu, Turkey
C. damascina	KJ553080	Arsuz, Turkey
C. damascina	KJ553043	Orontes, Turkey
C. damascina	KJ552896	Orontes, Turkey
C. damascina	KJ553272	Orontes, Turkey
C. damascina	KJ552846	Orontes, Turkey
C. damascina	KJ552874	Ceyhan, Turkey
C. damascina	KJ552797	Orontes, Syria
C. damascina	KJ553202	Orontes, Syria
C. damascina	KJ553027	Ceyhan, Turkey
C. damascina	KJ553194	Ceyhan, Turkey
C. damascina	KJ552763	Ceyhan, Turkey
C. damascina	KJ552939	Jordan River Drainage, Syria
C. damascina	KJ553216	Orontes, Turkey
C. damascina	KJ553089	Orontes, Turkey
C. erhani	KJ552767	Ceyhan, Turkey
C. erhani	KJ552087	Ceyhan, Turkey
C. erhani	KJ552806	Ceyhan,Turkey
C. erhani	KJ553067	Ceyhan,Turkey
*C. mandica**	KU564301	Ghare Aghaj River, Mond River basin, Khaneh Zanian, Iran
*C. mandica**	KU564302	Ghare Aghaj River, Mond River basin, Khaneh Zanian, Iran
*C. mandica**	KU312368	Ghare Aghaj River, Mond River basin, Khaneh Zanian, Iran
C. pestai	KJ553304	Egirdir, Turkey
C. pestai	KJ553138	Egirdir, Turkey
C. pestai	KJ552113	Egirdir, Turkey
C. pestai	KJ552841	Egirdir, Turkey
C. pestai	KJ552818	Egirdir, Turkey
C. tinca	KJ553229	Simav, Turkey
C. tinca	KJ553168	Simav, Turkey
*C. trutta**	KU312352	Karkheh River, Tigris River basin, Seymareh, Iran
*C. trutta**	KU312351	Gavi River, Tigris River basin, Illam, Iran
C. turani	KJ553224	Ceyhan Nehri, Turkey
*C. saadii**	KU312358	Saadii Tomb Spring, Maharlou basin, Iran
*C. saadii**	KU312395	Spring Pirbanoo, Maharlou basin, Iran
*C. saadii**	KU312360	Helleh River, Helleh basin, KohmarSorkhi, Iran
*C. saadii**	KU312361	Helleh River, Helleh basin, KohmarSorkhi, Iran
*C. saadii**	KU564299	Kor River, Kor basin, Kamfiruz, Iran
*C. saadii**	KU564300	Kor River, Kor basin, Kamfiruz, Iran
*C. saadii**	KU312359	Kor River, Kor basin, Kamfiruz, Iran

Species	Accession num.	Locality
*C. coadi**	KU564294	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564295	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564296	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564297	Beshar River, Tigris River basin, Iran
*C. coadi**	KU564298	Beshar River, Tigris River basin, Iran
Capoeta sp.	KJ552935	Dalaman, Turkey
Capoeta sp.	KJ553011	Büyük Menderes, Turkey
Capoeta sp.	KJ552882	Dalaman, Turkey
Cyprinus carpio	DQ868875	Unknown

Table 12. Diagnostic nucleotide substitutions found in mtDNA COI barcode region of *Capoeta* species. Nucleotide position relative to *Cyprinus carpio* complete mitochondrial genome.

Species	6545	6620	6626	6665	6683	6713	6749	6758	6761	6770	6818	6845	6875	6887	6905	6986	6995	7076	7088
C. buhsei	C	A	A	T	G	G	T	C	G	G	G	A	A	C	C	G	A	G	T
C. caelestis	T	G	C	T	G	A	G	T	G	A	A	C	G	T	T	G	G	G	C
C. coadi	C	A	A	T	A	G	T	C	G	G	G	A	A	C	C	A	A	G	T
C. damscina	T	A	G	T	G	A	G	T	A	A	G	C	A	T	T	G	G	A	C
C. saadii	T	A	A	C	G	G	T	C	A	A	G	A	A	C	C	T	A	G	T

Table 13. Diagnostic nucleotide substitutions found in *cyt* b of *Capoeta* species. Nucleotide position relative to *Cyprinus carpio* complete mitochondrial genome.

Species	15430	15451	15457	15463	15472	15526	15550	15610	15670	15682	15760	15814	15925	16011	16027	16039	16045	16063
C. buhsei	C	G	T	A	A	G	G	T	G	T	G	G	G	C	C	A	G	C
C. caelestis	T	A	C	A	A	G	G	A	A	C	A	A	G	T	T	G	A	T
C. coadi	T	G	C	A	G	G	A	C	G	T	G	G	G	C	C	A	G	C
C. damascina	T	A	C	G	A	A	A	T	A	T	G	A	A	C	T	G	A	T
C. saadii	T	G	C	G	A	A	A	T	A	T	G	A	A	C	T	G	A	T

The two different phylogenetic analyses produced similar topologies. Both analyses produced a tree with 3 major clades (Figs 6–7). These included Clade I) *C. antalyensis*, *C. baliki*, *C. banarescui*, *C. bergamae*, *C. buhsei*, *C. caelestis*, *C. coadi*, *C. damascina* (*C. angorae* is a synonym [Alwan 2011]), *C. kosswigi*, *C. mauricii*, *C. pestai*, *C. saadii*, *C. sieboldii*, and *C. tinca*, Clade II) *C. aculeata*, *C. ekmeckciae*, and *C. heratensis*, and Clade III) *C. barroisi*, *mandica*, *C. trutta*, and *C. turani*.

The Iranian members of the *C. damascina* species complex, clustered together and formed the sister group to the other members in the complex. In these trees, samples of the *Capoeta coadi*, from Beshar River in Tigris River basin, form a well-supported monophyletic group, sister to *C. buhsei* in clade I.

Table 14. Mean genetic distance for *cyt b* between *Capoeta* species.

	C. sieboldii	*C. caelestis*	*C. mauricii*	*C. bergamae*	*C. baliki*	*C. antalyensis*	*C. tinca*	*C. banarescui*	*C. turani*	*C. trutta*	*C. buhsei*	*C. coadi*	*C. mandica*	*C. saadii*
C. sieboldii														
C. caelestis	3.8													
C. mauricii	5.1	4.6												
C. bergamae	5.3	5.4	4.8											
C. baliki	4.4	4.7	4.5	5.7										
C. antalyensis	4.3	4.1	4.1	4.9	4.6									
C. tinca	5.3	5.6	5.3	6.6	1.0	5.6								
C. banarescui	5.7	4.9	4.9	6.0	4.9	4.4	4.9							
C. turani	8.1	8.4	9.3	9.5	8.5	8.6	8.8	11.0						
C. trutta	8.7	8.7	9.1	9.9	9.1	9.2	9.4	10.9	1.2					
C. buhsei	4.3	2.6	4.1	5.6	4.3	4.0	5.1	4.7	9.3	9.5				
C. coadi	4.2	2.6	4.5	6.0	5.0	4.3	5.8	5.4	9.4	9.6	1.5			
C. mandica	8.5	8.8	9.0	9.9	8.7	9.5	9.2	11.4	1.5	1.1	9.6	9.7		
C. saadii	4.8	3.3	4.8	4.6	4.7	4.8	5.4	5.8	8.5	8.9	2.8	2.7	9.1	
C. aculeata	6.5	6.6	7.2	7.7	7.4	6.5	8.0	7.5	9.2	9.2	6.8	7.0	9.7	6.8

Discussion

Based on morphological and molecular results, *C. saadii* and *C. coadi* are distinct species in the *Capoeta damascina* species complex group formerly known as *C. damascina* in Iranian water bodies. Phylogenetic analyses recovered three main groups inside the genus *Capoeta*: the Mesopotamian group (*C. trutta* group), the Anatolian-Iranian group (*C. damascina* group) and the Aralo-Caspian group (*C. capoeta* group) which is in agreement with Levin et al. (2012). The genus *Capoeta* is monophyletic (Levin et al. 2012). Based on the previous published data, the *Capoeta damascina* species complex group diverged from the *C. capoeta* group about 9.1 MYA (95% CI: 6.4–10.9) in the Tortonian period (Levin et al. 2012). Iranian members of the *C. damascina* group (*buhsei*, *saadii* and *coadi*) formed a clade sister to other *C. damascina* species complex group members.

The populations of *Capoeta* from the Karun River drainage have long been considered as *C. damascina* (Esmaeili et al. 2010). However, it has been proposed that *C. damascina* might be restricted to the Damascus area in Syria. Most Iranian populations, referred to *C. damascina*, including Karun River population have been considered as *C. saadii* (Heckel, 1847) (Teimori et al. 2016). *Capoeta saadii* was originally described from Persepolis, Pulwar (Sivand) River, Kor River basin, Ruins, northeast of Shiraz,

Table 15. Mean genetic distance for COI gene between *Capoeta* species.

	C. trutta	*C. heratensis*	*C. buhsei*	*C. coadi*	*C. saadii*	*C. pestai*	*C. caelestis*	*C. damascina*	*C. barroisi*	*C. bergamae*	*C. tinca*	*C. erhani*	*C. angorae*	*C. antalyensis*	*C. mauricii*	*C. mandica*
C. trutta																
C. heratensis	7.15															
C. buhsei	6.02	5.10														
C. coadi	6.01	5.23	0.44													
C. saadii	6.22	5.16	1.12	1.42												
C. pestai	5.82	5.07	3.83	3.60	3.82											
C. caelestis	6.03	4.54	2.61	3.10	2.88	4.01										
C. damascina	5.65	4.31	2.56	3.05	2.49	3.65	1.24									
C. barroisi	0.57	6.72	5.99	6.52	6.17	6.29	5.93	5.52								
C. bergamae	6.56	4.87	3.95	3.81	3.98	4.33	3.64	3.45	6.75							
C. tinca	4.39	5.32	4.50	4.77	4.49	5.02	4.44	4.01	4.21	4.47						
C. erhani	0.94	6.74	6.03	6.55	6.20	6.18	5.83	5.27	0.99	6.35	4.18					
C. angorae	6.37	4.68	3.28	3.41	3.02	3.97	1.91	0.74	6.27	3.78	4.46	5.97				
C. antalyensis	5.25	4.15	2.58	2.71	2.92	2.91	2.42	2.76	5.34	2.73	3.64	5.25	3.08			
C. mauricii	5.82	5.07	3.83	3.60	3.82	0.00	4.01	3.65	6.29	4.33	5.02	6.18	3.97	2.91		
C. mandica	0.42	7.31	6.22	6.34	6.39	5.99	6.20	5.83	0.73	6.54	4.58	1.18	6.54	5.43	5.99	
Cyprinus carpio	15.32	14.89	15.13	14.97	14.23	15.85	16.32	15.39	15.53	15.57	15.45	16.06	15.34	15.61	15.85	15.87

Iran. It was considered as a synonym of *C. damascina* (Esmaeili et al. 2010) and as a valid species by Bianco and Bănărescu (1982), by Levin et al. (2012) and by Teimori et al. (2016). Based on morphological and molecular results presented here, *C. saadii* is a valid species closely related to *C. buhsei* (as proposed by Bianco and Bănărescu (1982) and to *C. coadi* yet is diagnosed from these species and from *C. damascina* (see Alwan 2011). *Capoeta saadii* is the least known species of the genus. It is not mentioned in the revision of the genus by Karaman (1969) who had no specimens available, but its position within the genus *Capoeta* and its close phylogenetic relationship to *C. coadi* and *C. buhsei* were demonstrated using many fresh specimens at our disposal, mostly from type localities.

Comparative materials used in morphological and molecular phylogenetic analyses

Morphological analyses

Capoeta buhsei: ZM-CBSU Z218-229, 12, 104-149 mm SL; Iran, Semnan prov., Kavir basin, Hableh Rud at Garmsar, 35°18'06"N, 52°24'57"E. 21 August 2011. H.R. Esmaeili, G. Sayyadzadeh, A. Gholamifard, R. Zamaniannejad. ZM-CBSU Z260-274, 15, 88–130 mm SL; Iran, Albourz prov., Kordan River at Karaj, 35°57'12"N, 56°50'18"E. 5 July 2014. M. Masoudi, R. Khaefi. H.R. Mehraban.

Capoeta fusca: ZM-CBSU Z197-211, 15, 50–78 mm SL; Iran, south Khorasan prov., Sharifabad Qanat at Birjand, 33°58'08"N, 59°17'03"E. 29 August 2011. H.R. Esmaeili, G. Sayyadzadeh, A. Gholamifard, R. Zamaniannejad.

Capoeta mandica: ZM-CBSU Z230-234, 5, 82-130 mm SL; Iran, Fars prov., Qareh Aghaj River at Khaneh Zanian, 29°41'13"N, 52°05'58"E. 30 May 2015. H. Zareian, A. Gholamhosseini, G. Sayyadzadeh. ZM-CBSU Z212-217, 6, 83-118 mm SL; Iran, Fars prov., Qareh Aghaj River at Kavar, 29°10'55"N, 52°41'32"E. 27 February 2015. G. Sayyadzadeh, M. Masoudi.

Capoeta saadii: ZM-CBSU Z136-146, 11, 78-121 mm SL; ZM-CBSU 2504, 1, 82 mm SL; ZM-CBSU 2508, 1, 69 mm SL; ZM-CBSU 2520-2521, 2, 51-62 mm SL; ZM-CBSU 2524-2528, 5, 113-231 mm SL; Iran, Fars prov., Ghadamgah spring, Doroodzan, 30°15'11"N, 54°25'32"E. 21 December 2003. H.R. Esmaeili, Biglari.

Capoeta trutta: ZM-CBSU E100-123, 24, 50-149 mm SL; Iran, Kermanshah prov., Gamasiab River, 34°23'31"N, 47°42'57"E. 27 September 2007. A. Teimori, A. Gholamhosseini, M. Ebrahimi, A. Gholamifard; ZM-CBSU C453-463, 11, 67-177 mm SL; ZM-CBSU C474-477, 4, 67–75 mm SL; ZM-CBSU C481, 76 mm SL; all from Iran, Khuzestan prov., Maroon River at Aghajari, 30°44'52"N, 49°54'59"E. 21 March 2008. H. Zareian.

Molecular phylogenetic analyses

Capoeta buhsei; ZM-CBSU M1299-1300, 2, Iran, Albourz prov., Kordan River at Karaj, 35°57'12"N, 56°50'18"E. 5 July 2014. M. Masoudi, R. Khaefi. H.R. Mehraban. GenBank accession number: (COI: KU312349, KU312350; *cytb*: KU312369, KU312370); ZM-CBSU M1289-1290, 2, Iran: Semnan Prov., Kavir basin, Roudbar River at Mehdishahr, 35°37'56"N, 53°20'41"E. 30 August 2011. H.R. Esmaeili et al., GenBank accession number: (COI: KU564292, KU564293).

Capoeta heratensis; ZM-CBSU M813-815, 3, Iran, Razavi Khorasan prov., Gilas spring, 36°36'55"N, 59°20'17"E. 25 August 2011. H.R. Esmaeili et al. GenBank accession number: (COI: KU564288, KU564289, KU564290). ZM-CBSU M816, 1, Iran, Razavi Khorasan prov., Bezangan Lake, Tedzen basin. 36°17'03"N, 60°24'18"E. 25 August 2011. H.R. Esmaeili et al. GenBank accession number: (COI: KU564291).

Capoeta mandica: ZM-CBSU M1433-1435, 3, Iran, Fars prov., Qareh Aghaj River at Khaneh Zanian, 29°41'13"N, 52°05'58"E. 30 May 2015. H. Zareian, A. Gholamhosseini, G. Sayyadzadeh. GenBank accession number: (COI: KU564301, KU564302, KU312368; *cytb*: KU564307, KU564308, KU312375).

Capoeta saadii: ZM-CBSU M1426-1427, 2, Iran: Fars prov. Kor River, at Kamfirouz, 30°25'2"N, 52°8'59"E. H. Zareian. 24 October 2015. GenBank accession number: (COI: KU564299, KU564300; cytb: KU564312, KU564313). ZM-CBSU M1421, ZM-CBSU1422-1425, 3, Iran, Fars prov., Qareh Aghaj River at Firuzabad, 28°41'31"N, 52°27'43"E. 25 April 2015. H. Zareian. GenBank accession number: (*cytb*: KU564309, KU564310, KU564311). ZM-CBSU M157, 1, Iran, Fars prov., Shiraz, Saadii Tomb, Maharlou basin, 29°37.348'N, 52° 34.934'E. R. Khaefi, 2009. GenBank accession number: (COI: KU312358). ZM-CBSU M825, M831, 2, Iran, Fars prov., Helleh River, Helleh basin, KohmarhSorkhi, S. Mirgheiasi, S. Ghasemian. 29°23'39"N, 52°09'49"E. GenBank accession number: (COI: KU312361, KU312360; *cytb*: KU312373). ZM-CBSU M822, 1, Iran, Fars prov., Qareh Aghaj River at Firuzabad, 29°07'34"N, 52°51'24"E. GenBank accession number: (*cytb*: KU564310). FSJF DNA-18 Iran: Fars prov.: spring Pirbanoo about 10 km south of Shiraz, 29°31'08"N, 52°27'55"E GenBank accession number: (COI: KU312395). FSJF DNA-22; Iran: Fars prov.: River Kor about 73 km north of Shiraz, 30°11'37"N, 52°27'56"E. GenBank accession number: (COI: KU312359).

Capoeta trutta: ZM-CBSU M583, 1, Iran: Ilam prov.; Gavi River at Mehran, H.R. Esmaeili, 13 November 2012, 33°39'18"N, 47°02'14"E. GenBank accession number: COI: KU312351; ZM-CBSU M593, 1, Iran, Ilam prov.; Seymareh River, H.R. Esmaeili, 13 November 2012, 33°38'17"N, 47°01'30"E. GenBank accession number: COI: KU312352.

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